

International Conference on Applied Internet and Information  
Technologies, 2016

DOI:10.20544/AIIT2016.32

## E-health monitoring system

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**Abstract.** Monitoring of patients' vital parameters very often is limited to hospitals or other health care centres, which makes the process time consuming and expensive. Rapid advancement in information and communication technologies offers great opportunities for development of remote monitoring systems, which on one hand, will reduce costs and travel time, and on the other will increase health service efficiency and user satisfaction. The goal of this paper is to propose an e-health system that allows doctors to closely monitor patients' vital parameters, no matter where they are located. Integration of web, mobile and smart TV technology, will provide greater accessibility of patients' data, and will improve patient – doctor communications.

**Keywords:** e-health, mobile, Smart TV, web services.

### 1. Introduction

Advanced information and communication technologies, offering anywhere and anytime connectivity, play a key role in the development of a modern healthcare systems [1]. Various online systems for monitoring and collecting patient data exists nowadays. This kind of solutions are very useful especially when a treatment includes monitoring of some vital parameters for long period of time.

There are a number of researchers focusing their activities in this research area. Ostmark et al. [2] proposed sensor system that acts as a Bluetooth device providing a TCP/IP interface for configuration and maintenance and allows user interaction through standard WWW-browser technology. Their concept is based on mobile wireless EIS (Embedded Internet System) sensor platform. Hung and Zhang [3] described the implementation and experiences with a WAP-based telemedicine system for monitoring. Authorized users can access to patients' general data, and can monitor blood pressure and electrocardiogram on WAP devices in store-and-forward mode. Sorwar and Hasan [4] proposed an integrated tele-monitoring framework for supporting patient monitoring process. They used Smart TV technology for interaction between patient and health care providers. Arcelus et al. [5] used a sensor technology integrated in a home-based system that monitors patients'

health. They also proposed a framework for data processing. Chan et al. [6] focused their work on multi-sensor home monitoring system developed to help elderly people, by observing mobility changes indicative of abnormal events. The proposed system is only one part of their final goal - to build an abnormal event diagnosis system to help elderly people living alone. Similar system that provides an end-to-end solution is described by Agarwal and Lau [7]. Authors described a remote health monitoring service that collects blood pressure readings from a patient through a mobile phone and make them available to the doctors through a web interface. Yong et al. [8] developed a health monitoring system based on smart phones. 3G or Wi-Fi network is used for transferring data to a remote healthcare server, that can monitor multiple users in real-time. Sapal et al. [9] and Silva et al. [10] review some new technologies for making remote monitoring and health care process more flexible and convenient. Additionally, authors present a comprehensive review of the state of the art on m-Health applications.

In this paper we propose a remote monitoring system, for a healthcare delivery outside of hospitals, in order to reduce costs and travel times, from one site, and to improve quality of patient care, from the other. The system can be used for monitoring vital parameters data, such as: blood pressure, heart rate, body temperature, respiratory flow, glucose, weight etc. Because of the nature of these health parameters, their values must be monitored and controlled on a regular (daily, weekly or monthly) basis.

The proposed system integrates web, mobile and smart TV technologies, which ensure greater visibility and interaction between doctors and patients. The system can capture, organize and display patient data using a customizable user-friendly interface.

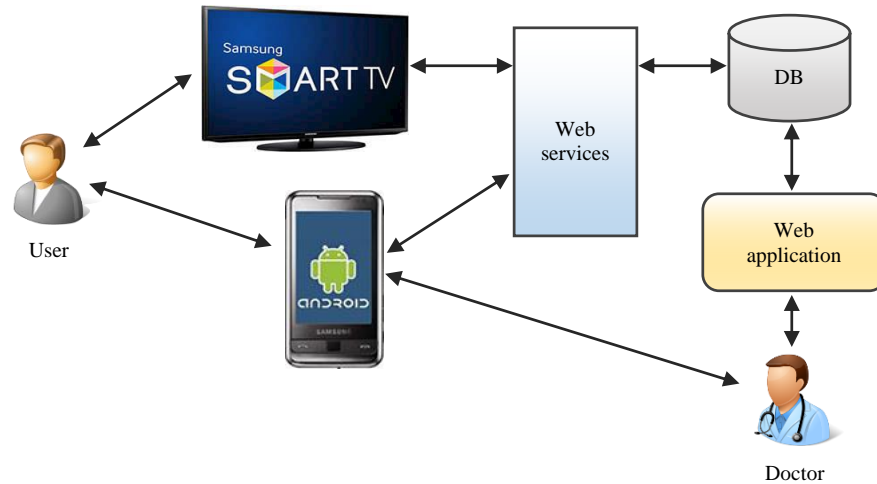
Proposed system can be used for healthcare of elderly living alone in their homes, patients in rural areas, as well as chronically ill patients that have high level of medical need.

## **2. E-health monitoring system**

The e-health system, described in this paper, will be used for monitoring of patients' vital physiological data. It is composed of three modules: web, mobile and Smart TV module, which cover the essential features for a remote monitoring healthcare system. The system can collect required vital data and make them visible to doctors. Doctors can act upon them (suggest or modify the therapy for example). Additional functionalities like generating and displaying a group overview chart having one data point for each patient, are also implemented.

To ensure compatibility with other systems, we are using Open m-Health platform for data collection and visualization. All modules use common database (MS SQL). The mobile and Smart TV application use web services for interaction with database.

Web application is accessible from every device that has Internet connection. As far as for mobile and Smart TV application, it can be downloaded and installed on appropriate user devices.



**Fig. 1.** General architecture of developed e-health system

- **Web application** has two type of users: patients and doctors.  
Each patient has access to his own profile. Patient can see medications and dosages prescribed by doctors, as well as some information, notes and advices. He can insert, on a daily basis, measured values for his controlled parameters, like: hart rate, body temperature, blood pressure, blood sugar, current weight etc.  
Doctors have full access to all patients' records due to the need for managing the long term care regime for the patient. They can add notes and advices, prescribe medications, suggest therapies, insert appointments and send internal messages to the patients. They can also view the data entered by patients and refer to their vital parameters.  
Web-application allows two types of data presentation modes: table and graphical. Doctors can use this data within the decision process for prescribing new therapy for the patient, if necessary.
- **Mobile application** is the second part of the proposed system. It is developed in Eclipse using Java programming language. The mobile application has the same functionality as the web application, which allows access to patients' data from anywhere and anytime.
- **Smart TV application** is developed using Samsung Smart SDK. It can be used by patients as a reminder for their daily activities, like taking medications on time or going to medical appointment. Smart TV application shows notifications 15 minutes or 1 hour before some activity (depending on the activity type). This application was designed with the idea that a lot of people, while staying at home, are watching TV. So, using the Smart TV platform for creating a reminder application would be an ideal solution.

### 3. User interface design

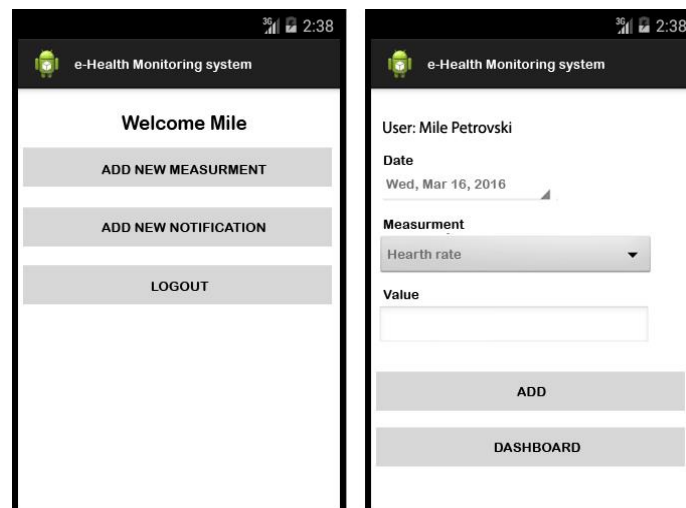
Taking into account that most of the patients are elderly people, a great deal was putted on user interface design. After extensive analyses on other similar medical applications, and design recommendations proposed in different research studies, a GUI for web, mobile and smart TV applications was designed. Large font size, easy readable typeface, colour contrast, and sufficient blank spaces among the text and graphical items on the screen, were applied for the graphical output optimization.

Elderly people can be easily confused if they need to perform a number of operations to get some information. Having this fact in mind, the system was designed to reach the desired information in a fewer steps as possible. Considering the fact that very often the elderly are not able or willing to enter a lot of information by typing, the interface is designed so only important information need to be entered (e.g. measured values, medication, dosage etc.)

### 4. Usage scenario

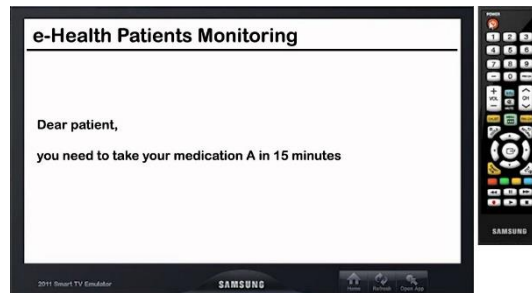
Access to the system have all users who already have a profile in the system. Creation of user profiles and managing some general information is responsibility of the administrator. After the profiles are created users can log on to the application using their credentials (provided by administrator).

Patient can use web or mobile application for inserting measured values for their controlled parameters. He can select one of the controlled parameters, after which an appropriate form for inserting values is presented. Patient can also choose if he wants to write some notes to the doctor.



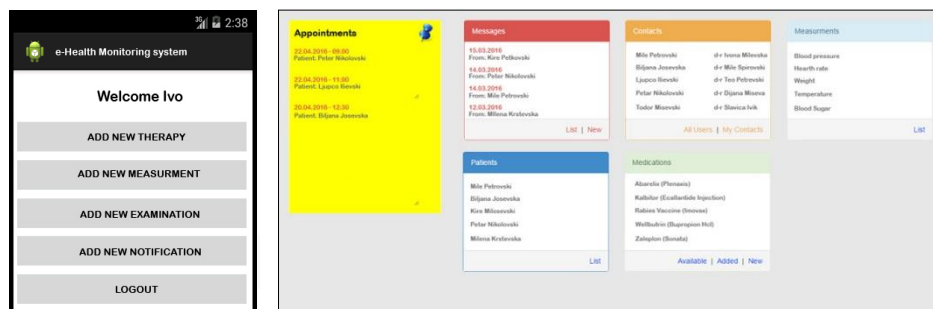
**Fig.3.** a).Mobile application dashboard for patient b) Inserting values for a specific parameter

Patient receives notifications about medications, or some appointment, using Smart TV applications. It is very important for the patient to take the prescribed medication on time, so the notification window will stay active until the patient turned it off.



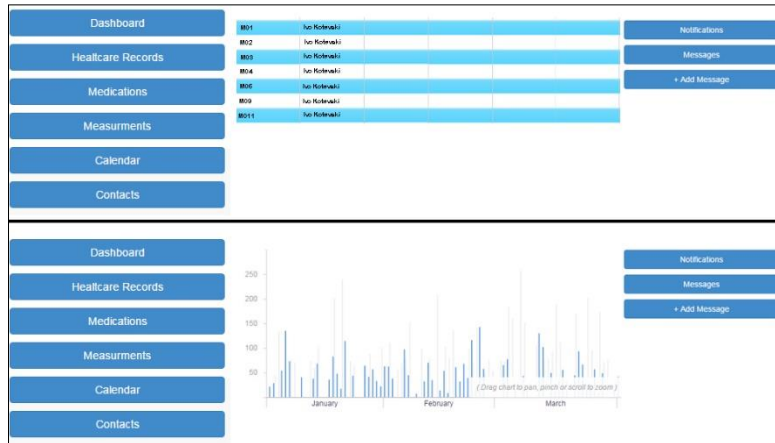
**Fig. 4.** Smart TV notification

Doctors can check patients' medical record, can suggest therapy or prescribe medications using web-based application or a mobile application. After successful login action, doctors can select a desired activity from the application dashboard.



**Fig. 5.** Applications dashboard for doctors (a. mobile application b. web application)

After selecting the patient, from a patient list, doctors can also see patient medical records. The data added by the patients can be presented as a table or a graphic.



**Fig. 6** Overview of patients' medical record

Furthermore, the doctor can add new values for some pre-defined medical parameters.

**Fig. 7.** Adding new values for pre-define health parameters

Adding a note or suggestion for the patient is done by clicking the "New" hyperlink in Contact section. For sending this note/suggestion to the patient, doctor should click the Save button, after which the text is stored in the database and is available for further review by the patient.

## 5. Conclusion

In this paper a low cost e-health monitoring system was proposed. The system offers remote capabilities that enhance the level of medical support the patient receives while enabling them to be monitored in the comfort of their home. This is especially important for patients with chronic diseases and patients that require regular monitoring of vital parameters.

Using web or mobile application, patients' data can be collected easily and efficiently, at the same time providing access to them from any location. Visualisation of this data as

well as tracking the progress and facilitating communication between patients and doctors, are considered as a great advantage of this solution.

Taking the medicine on time is considered to be a high priority for patients. Failure to take the medicine on time cannot only delay recovery, but can worsen the symptoms of an existing illness or cause serious side effects. In this context the use smart TV application for showing reminders and notifications, is very important.

Our next step will be conducting the evaluation study with the end users in order to get the feedbacks from them, which will be used for further system improvement.

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